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# NAVORD REPORT

4276

EFFECT OF VACUUM MELTING VERSUS EVACUATION OF MELT ON DENSITIES  
OF CAST TNT EXPLOSIVE CHARGES

# FC

16 APRIL 1956



**U. S. NAVAL ORDNANCE LABORATORY**  
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EFFECT OF VACUUM MELTING VERSUS EVACUATION OF  
MELT ON DENSITIES OF CAST TNT EXPLOSIVE CHARGES

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ABSTRACT: Pentolite was selected as an example of a TNT containing explosive for use in the subject investigation. Pentolite was evacuated in two different ways to determine which method would yield higher density castings. In the first case the material was melted under atmospheric pressure, then evacuated; in the second case evacuation was started before melting. The products obtained from these two methods had densities which were, for all practical purposes, the same.

Separately, it was found that melting pentolite at reduced pressure (1.5 mm of mercury) took an average of one fifth more time than it did at atmospheric pressure.

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This investigation was carried out under Task Assignment NOL-S3-2c-22-1-56 in order to compare the characteristics of charges made by procedures described herein.

The data are for information only and are not intended as a basis for action. Any opinions expressed are those of the author.

W. W. WILBOURNE  
Captain, USN  
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By direction

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EFFECT OF VACUUM MELTING VERSUS EVACUATION OF  
MELT ON DENSITIES OF CAST TNT EXPLOSIVE CHARGES

INTRODUCTION

Explosive charges of maximum density cannot be cast from material which has been melted in contact with air under atmospheric pressure. Castable explosives, specifically those containing TNT, dissolve gaseous components of the atmosphere during melting and subsequent agitation while exposed to air. The dissolved gases form small bubbles when the explosive solidifies thereby reducing the density of the casting. These facts have been reported by the Armour Research Foundation, reference (a), and by Picatinny Arsenal, reference (b) and (c).

This solution of gases and the objectionable dissolution have been avoided experimentally and practically by melting explosives in vacuo, reference (b) and (c). When the Cornhusker Ordnance Plant was reactivated in 1950, the equipment installed for loading the 3.5-inch M28A2 HEAT Rocket included vacuum melting kettles.

Experiments have proved that no additional worthwhile improvement, increase in density, can be obtained by casting explosive charges under reduced pressure, reference (b) and (c).

About two years ago the replacement at this activity of open kettles by melting kettles that could be evacuated during melting was begun. At present there are two such kettles in use, of 8 quart and 5 gallon capacities. A third kettle will be added in June.

Experience of the operators indicated that melting under vacuum is slower than open kettle melting and that evacuation subsequent to melting accomplishes satisfactory de-aeration. The second conclusion was corroborated by the higher density of the explosive charges produced from evacuated melts.

The work reported herein was undertaken to determine conclusively whether complete de-aeration can be obtained by evacuation of the melt and time required for de-aeration. A second objective was determination of rate of melting in vacuo and under atmospheric pressure.



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Pentolite 50/50 was used in these experiments. Inasmuch as the results are not surprising, it is believed that the conclusions are applicable to other explosives. Similar experiments with other explosives are believed to be unnecessary.

EXPERIMENTAL PROCEDURE

The following experiments were carried out in the pilot plant using pilot plant equipment. The densities of castings made by the following methods were compared.

METHOD A. Pentolite (X-187, Lot Rad 1406) from a fresh box was mixed by quartering in order to obtain a homogeneous sample. Seven and one half kilograms were melted at atmospheric pressure over a period of 25 minutes by adding small increments into a 5 gallon steam-jacketed, vacuum kettle supplied with an anchor-type agitator. When thoroughly melted, the heat was shut off and the vacuum applied, attaining a vacuum of 3.5 mm of mercury in another 25 minutes. The melt was left at this pressure for 40 minutes. (All this time steam was supplied intermittently in order to keep the explosive in a fluid state). The pressure was then brought back to atmospheric. The melt was cooled to 83°C. (from 86.5°C.) then poured into twelve numbered molds (steel cylinders 1-5/8" dia. x 6"), having paper risers, which had been previously warmed to 65°C. After cooling to room temperature the densities of the castings were determined.

METHOD B. Seven and one half kilograms of the same quartered pentolite as above were placed in the kettle all at once. The kettle was evacuated without heating. A vacuum of 3.5 mm pressure was attained in 23 minutes, at which time heat was applied. A period of 25 minutes was now allowed for melting. The melt was then kept at this pressure 40 minutes longer (total time under 3.5 mm pressure = 1 hr. 5 minutes). It was then allowed to return to atmospheric pressure. (Small streaks of foam were noticeable on the surface of the melt. These were absent in METHOD A.). As its temperature was already 83°C., the melt was immediately poured in the same twelve molds preheated to 65°C. The densities of the cold castings were calculated and averaged for each trial:

METHOD A gave an average density of 1.687  
METHOD B gave an average density of 1.685

MELTING OF PENTOLITE UNDER REDUCED PRESSURE

Pentolite (50 grams) was placed in a 200 ml. round bottomed flask supplied with a dial thermometer, with an L-shaped piece

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of glass tubing serving as an outlet. The flask was submerged to its neck in a water bath kept constantly at 100°C. by means of live steam. The flask was agitated manually, and the time it took for the temperature to go from 26°C. to 90°C. (a temperature of conveniently high fluidity) was recorded. The experiment was conducted both at atmospheric pressure and at a pressure of 1.5 mm of mercury. This set of experiments was repeated five times with the following results:

Table I

Time Required to Melt Pentolite and Heat to 90°C.

	<u>Atmospheric Pressure</u>	<u>At 1.5 mm Pressure</u>
Trial I	10 Minutes	10 Minutes
Trial II	7 "	10 "
Trial III	9 "	11 "
Trial IV	6 "	9 "
Trial V	6 "	10 "
Average	7.6 Minutes	10 Minutes

SUMMARY

These experiments have demonstrated two things. (1) The density of the cast explosive is not improved by submitting the explosive to high vacuum both in the solid and in the melted state. Evacuation of the melted explosive is sufficient. This is shown by the densities obtained for METHOD A. (1.687) and METHOD B. (1.685), which should be considered the same because the third decimal fraction is uncertain. (2) Under vacuum, melting of the explosive is retarded. This is borne out in Table I, where the data shows that on the average, 30% more time is required for melting under 1.5 mm pressure than under atmospheric pressure. It must be borne in mind, however, that, depending on the conditions of the experiment (such as size of batch, type of agitation, etc.) this difference will vary to some extent. The significant fact remains, however, that a longer time is required to melt under reduced pressure than under atmospheric pressure, other factors remaining the same.

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Aside from the academic interest which the above findings may have, they confirm the efficacy of the present practice, wherein the explosive is first melted, then de-aerated by evacuation.

A handwritten signature in cursive script, reading "Virgil Milani".

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Virgil Milani  
Explosives Properties Division

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REFERENCES

- (a) Armour Research Foundation of Illinois, Institute of Technology, Casting of TNT, Supplement to the Final Report by W. C. McCrone and D. E. Laskowski, Chicago 16, Illinois, Project No. 90-1138C, Restricted, August 20, 1952
- (b) Samuel Feltman Ammunition Laboratories, Picatinny Arsenal Technical Report 2147, Effect of Removal of Air from Cast High Explosives on the Properties of These Explosives and the Performance of Small Experimental Shaped Charges, March 1955
- (c) Samuel Feltman Ammunition Laboratories, Picatinny Arsenal Technical Report 2155, Deaeration of Explosives in the Melting Kettle as a Means of Improving the Performance of the 3.5 Inch Heat Rocket Head, March 1955

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